The Journey from Jack Bore to HDD

Joe Pikas and Drew Lafleur, Technical Toolboxes, USA, reflect on advancements from Jack Bore to Horizontal Directional Drilling construction methods and how to maintain pipeline integrity for the long term.

Technical Toolboxes is a leading provider of integrated desktop and cloud-based pipeline engineering software, online resources, and specialised training for pipeline engineering professionals around the world. The company's pipeline engineering subject matter expert, Joe Pikas, has 55 years of experience in pipeline construction, operations, corrosion, risk and integrity in the oil, gas, water, and nuclear industries. He has been involved with the continued development of Technical Toolboxes' Pipeline Toolbox, RSTRENG+, HDD and AC Mitigation software programmes and is a true believer in leveraging technologies to improve midstream performance. Drew Lafleur is the company's President and CEO, and brings expertise in digital transformation and integrated operations to reimagine the marriage of software user experience with knowledge transfer to deliver a safer, greener future for the midstream industry.

In 1966, Joe Pikas was starting his first 42 in. natural gas pipeline engineering construction project for a large natural gas company in the engineering survey crew. One of the many tasks was to set alignment and elevation for each Jack Bore (JB) at all road and rail crossings. JB is a method for installing a casing that serves as a conduit for gas and oil product pipelines. This is a non-steerable technology, so a pit has to be dug on both sides of the road/railway for the boring machinery to fit in, and bore in a straight line underneath the surface. As with most industrial processes, there are many challenges to overcome, details to pay attention to, and balancing the minimum safe depth of the pipe with the soil, water, and rock content of the pit elevation for the launching pit and receiving pit was an ongoing challenge. Horizontal Directional Drilling (HDD) was just getting started as a new technology in the early 1960s and was not available for this project. Had HDD been a viable tool in this project, many efficiencies would have been gained and there could have been less disturbance of the environment through avoiding the need for the pits. Nonetheless, the operator and the boring contractor aligned on a project plan and the pipeline ended up exactly as it was originally designed to be located.

A brief history of HDD

HDD is a steerable, trenchless method of installing a pipeline. This enables equipment to remain on the surface, eliminating the need for the launching and receiving pits, as well as making it feasible to cross deeper and longer obstacles. Pipeline installation by HDD has progressively gained popularity over the last five decades. In the 1970s, HDD saw its first successful river crossing with a small diameter pipe and progressed to enable the 40 in. pipes to traverse under rivers. In the 1980s, the technology improved to enable tracking the location of the drill bit from the surface, thereby opening the door for significant efficiency and accuracy improvements. Today, it is the preferred method for trenchless installation of pipelines across major natural and manmade obstacles such as water bodies and roadway, ravines, railway, runways and other structures. HDD enables safe and efficient installation of pipelines, including long distances and complex designs with many curves. HDD precision now enables trenchless pipeline installation in congested areas with various geohazards and other infrastructure to avoid.

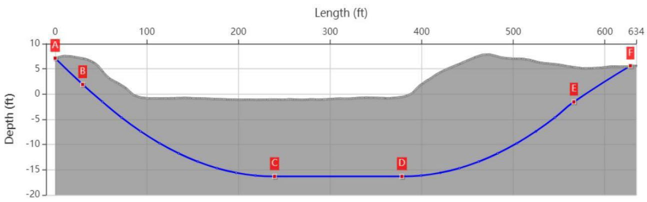

Figure 1. Profile view of a borehole path design.

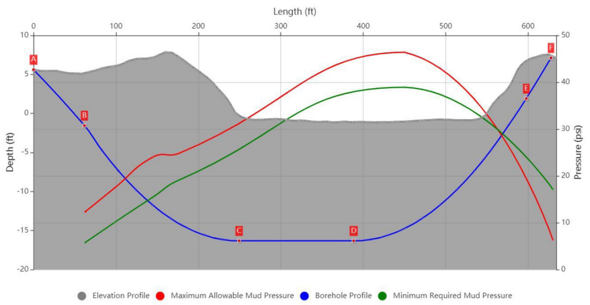

Figure 2. Borehole stability analysis.

Project methodology

A design starts by defining the geometry of the bore path. Bore hole geometry is a very important consideration in a long HDD project (Figure 1). Optimal bore geometry ensures minimum pull force, and reduces the likelihood of coating damage. It also reduces both installation stress and operational stress on the pipeline. In Joe's 1966 project example, there was a straight bore from entry point to exit point; no curves were in the design, so pull-force strain and coating damage were lesser concerns, whereas curves in two planes, or compound curves, are common today.

An HDD operation starts by drilling a pilot hole that is made with API steel drill pipe, with a diameter sufficient for the torque, longitudinal load and fluid pressure required for the work. A mud motor drilling bit is used for making the pilot hole. The drill bit is tracked in 3-dimensional co-ordinates, to ensure that the drill path follows the design. Precautions are taken to avoid hitting the existing buried structures in the same depth. Entry and exit points are located 10 ft from the centreline of the existing pipeline. Once the drill bit reaches the exit point, it must travel back through the pilot hole with a reamer to enlarge the bore hole, and must pull the pipe that is being installed through the bore hole as well.

The drilling fluid is prepared onsite and must be designed to lubricate the bit, keep the hole open without fracturing adjacent rock, transport cuttings back to the surface, and develop a filter cake on the bore walls to prevent the drilling fluids from leaching into soils. Good drilling fluid circulation must be maintained with no spills, no waste and no 'frack-out' of the drilling fluid. Therefore, a borehole stability analysis must be done before any work can begin (Figure 2).

With all the constructability benefits of HDD comes some disadvantages, especially from a pipeline maintenance, corrosion control and integrity management point of view. Pipeline segments using HDD can impose additional strain on the pipeline during the pull through process and can significantly increase both installation stress and operational stress of the pipeline. HDD installed pipelines are relatively deep and could easily become low points for liquid hold up causing flow issues. Such low points tend to accumulate corrosive species, thereby causing internal corrosion problems. HDD installation also increases the likelihood of external coating damage during pull through of the carrier pipeline. Significant external coating damage can easily expose the pipeline to corrosive species in the soil, and depending on the depth, conventional methods of detecting coating damage and monitoring possible external corrosion conditions of the pipeline may not be sufficient to detect these defects.

Enhancing pipeline engineering performance

The key to success is proper merging of people, processes, and technology to meet operational challenges. Much like the revolutionary transition from jack bore to HDD for trenchless pipe installation enabled great progress in constructability, the current digital transformation that is underway enables strides to be made in efficiency and sustainability. From a design perspective, an engineer must balance the time that is available for a project with how much time is spent perfecting the design. Software can enable a paradigm shift in how these engineers spend their time. For example, by dramatically reducing the tasks of data mining, QC, data entry and model configuration that can consume the majority of the time spent on a project, the engineer is empowered to spend much more time engineering better outcomes during the design phase, including mitigating long term integrity risks.

Technical Toolboxes' pipeline engineering software platform helps reduce risk, lower total cost of operations and accelerate project schedules. As pipeline engineering professionals embrace digital change, Technical Toolboxes' legacy applications are evolving into sophisticated, integrated holistic analysis tools that enable users to make efficient, accurate decisions. The recently released Pipeline HUBPL platform which includes the HDD Power Tool (HDDPT) automates integration and analyses for insights into infrastructure design and operational fitness. It connects a library of engineering standards and tools to users' data across a pipeline lifecycle. Integrated maps allow geospatial analysis, visual reconnaissance of existing databases and leveraging of disparate geographical information systems (GIS) data components.

Conclusion

Advancements in machinery and instrumentation technologies were key in progressing constructability of pipelines in congested areas in the 20th century. In the 21st century, key advancements are being made for operability and long-term integrity as the industry develops improved knowledge bases and processes to address post-installation stress, coating damage, and other challenges that arise from the complex designs enabled by HDD. Each HDD installation should be uniquely designed and installed to specific site conditions, such that it will not present a pipeline integrity nightmare down the road and will keep hydrocarbons in the pipe. Sound engineering practices must be followed, and there are many complex engineering decisions to be made in the pre-planning, design, borehole stability analysis and adjusting on-the-fly during installation of the pipeline to make sure the HDD segment does not turn out to be a problem from a maintenance, corrosion control and an integrity (regulatory) point of view. The digital transformation that is underway in the industry can greatly improve safety and environmental stewardship. A key differentiator in successful digital transformations is the combination of people and processes with the technology, and software selection can greatly influence the outcome.